Overall Diet History and Reversibility of the Metabolic Syndrome Over 5 Years

The Whitehall II prospective cohort study

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OBJECTIVE — We examined the impact of adherence to the Alternative Healthy Eating Index (AHEI), a set of dietary guidelines targeting major chronic diseases, on metabolic syndrome (MetS) reversion in a middle-aged population.

RESEARCH DESIGN AND METHODS — Analyses were carried out on the 339 participants (28% women, mean age 56.4 years) from the Whitehall II study with MetS as defined by the National Cholesterol Education Program Adult Treatment Panel III criteria. Reversion was defined as not having MetS after 5 years of follow-up (158 case subjects).

RESULTS — After controlling for potential confounders, adherence to AHEI was associated with MetS reversion (odds ratio 1.88 [95% CI 1.04–3.41]), predominantly in participants with central obesity and in those with high triglyceride.

CONCLUSIONS — Our findings support the benefit of adherence to AHEI dietary guidelines for individuals with MetS, especially those with central obesity or high triglyceride levels.

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The metabolic syndrome (MetS), prevalence estimated at between 10 and 25% in adult populations worldwide (1), is associated with an increased risk of type 2 diabetes and cardiovascular diseases (CVDs). Lifestyle modification, such as increased physical exercise (2) and diet therapies (3,4), may have a beneficial impact on MetS. We examined a set of dietary guidelines targeting major chronic diseases known as the Alternative Healthy Eating Index (AHEI) (5). Our goal was to examine whether adherence to AHEI was associated with reversion of the MetS over a 5-year period in a middle-aged population.

RESEARCH DESIGN AND METHODS

Data came from phases 3 (1991–1993), 5 (1997–1999), and 7 (2002–2004) of the Whitehall II study of London-based office workers (6). From the 3,698 participants with complete data on MetS at phases 3 and 5, diet and covariates at phase 5, and MetS reversion between phases 5 and 7, the 339 case subjects with MetS at phase 5 formed the study population for the main analysis.

At each phase, MetS was defined using the National Cholesterol Education Program Adult Treatment Panel III criteria (7). The definition of each MetS component and details of other measurements are given in the footnote of Table 1 and have been described previously (8). The 5-year reversion of MetS was defined as not having MetS at phase 7.

Dietary intake data were collected via a validated 127-item food frequency questionnaire (FFQ) (9–10) at both phases 3 and 5. AHEI score (5) was created by summing its nine component scores (1/fruits, 2/vegetables, 3/ratio of white to red meat, 4/*trans* fat, 5/ratio of polyunsaturated to saturated fat, 6/total fiber, 7/nuts and soy, 8/alcohol consumption, and 9/long-term multivitamin use); a higher score corresponded to greater adherence (online appendix Table A1, available at http://care.diabetesjournals.org/cgi/content/full/dc09-2200/DC1). We used the AHEI measures in two ways: the phase 5 score was used for the main analysis, and the average AHEI score across phases 3 and 5 was used to take into account longer-term adherence to AHEI in a subsidiary analysis on the 337 participants with complete dietary data from phases 3 and 5. Levels of AHEI adherence at phase 5 were comparable to those reported in two large American cohorts (5) (online appendix Table A2).

Logistic regression models examined the association between tertiles of the AHEI scores at phase 5 and reversion of MetS and of its components at phase 7, sequentially adjusted for age, sex, ethnicity (White, non-White) and total energy intake (kcal/day) (model 1) and additionally for educational attainment (no academic qualification, lower secondary, higher secondary, university degree, higher university degree), marital status (married or cohabiting, living alone), smoking (current, former, nonsmoker), persistence of MetS at phase 5 (having MetS at both phases 3 and 5), depressive symptoms, and intensity of physical activity (high, medium, low) (8) (model 2). No significant interaction between AHEI scores and covariates (including sex) was observed. Analysis was conducted using the SAS software, version 9.1 (SAS Institute).

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Table 1—*Association between adherence to the AHEI and 5-year reversion of the MetS*

		Model 1*	Model 2†
Total	339		
Low AHEI score‡	115 (48)	1.00 (reference)	1.00 (reference)
Intermediate AHEI score§	111 (50)	1.20 (0.69–2.08)	1.15 (0.65–2.05)
High AHEI score‖	113 (60)	1.73 (0.99–3.02)	1.88 (1.04– 3.41)
P¶		0.05	0.04
Subcohort with central obesity	212		
Low AHEI score‡	71 (25)	1.00 (reference)	1.00 (reference)
Intermediate AHEI score§	76 (30)	1.34 (0.67–2.67)	1.29 (0.61–2.76)
High AHEI score‖	65 (33)	2.35 (1.12–4.96)	2.77 (1.19–6.44)
P¶		0.025	0.02
Subcohort with high triglycerides	294		
Low AHEI score‡	103 (43)	1.00 (reference)	1.00 (reference)
Intermediate AHEI score§	92 (38)	1.07 (0.58–1.94)	1.01 (0.54–1.89)
High AHEI score‖	99 (54)	1.92 (1.06–3.49)	1.94 (1.04–3.65)
P¶		0.03	0.04
Subcohort with low HDL cholesterol	198		
Low AHEI score‡	65 (28)	1.00 (reference)	1.00 (reference)
Intermediate AHEI score§	60 (27)	1.00 (0.47–2.12)	1.03 (0.45–2.36)
High AHEI score‖	73 (38)	1.37 (0.67–2.81)	1.58 (0.70–3.55)
P¶		0.36	0.26
Subcohort with hypertension	279		
Low AHEI score‡	98 (45)	1.00 (reference)	1.00 (reference)
Intermediate AHEI score§	90 (42)	1.09 (0.60–1.99)	1.08 (0.57–2.02)
High AHEI score‖	91 (48)	1.48 (0.80–2.73)	1.61 (0.84–3.08)
P¶		0.21	0.15
Subcohort with high glucose	131		
Low AHEI score‡	39 (13)	1.00 (reference)	1.00 (reference)
Intermediate AHEI score§	51 (22)	1.48 (0.59–3.70)	1.41 (0.51–3.89)
High AHEI score‖	41 (21)	2.08 (0.80–5.43)	2.52 (0.81–7.88)
P¶		0.13	0.11

Data are *n*, number of participants (number of reversion cases), or odds ratio (95% CI) for MetS reversion. MetS was defined using the NCEP definition (7) based on the presence of three or more of the following: waist circumference (men >102 cm, women >88 cm), serum triglycerides (≥1.7 mmol/l), HDL cholesterol (men <1.04 mmol/l, women <1.29 mmol/l), blood pressure (≥130/≥85 mmHg systolic over diastolic pressure), fasting glucose (≥6.1 mmol/l), or presence of type 2 diabetes. Waist circumference was taken as the smallest circumference at or below the costal margin. Resting blood pressure was measured with the participant seated using the Hawksley random zero sphygmomanometer (phases 3 and 5) and the OMRON HEM 907 (phase 7). Serum triglycerides, HDL cholesterol, and fasting blood glucose were analyzed as previously described (8).*Model 1: adjusted for sex, age, ethnicity, and energy intake. †Model 2: model 1 additionally adjusted for education, marital status, smoking habits, physical activity, persistence of MetS, and depressive symptoms. ‡Low AHEI adherence: median (range), 39.5 (3.5–43.5). §Intermediate AHEI adherence: 50.5 (44.5–55.5). ‖High AHEI adherence: 62.5 (56.5—76.5). ¶*P* value of the comparison between high vs. low AHEI score.

RESULTS — Among the 339 participants with MetS at phase 5, 158 (46.6%) recovered by phase 7. Characteristics of the participants (as a function of MetS reversion and AHEI category) are shown in online appendix Tables A3 and A4. After controlling for potential confounders, adherence to AHEI was associated with increased odds of MetS reversion over the 5-year follow-up (Table 1). This association was stronger among participants with MetS at both phases 3 and 5 (*n* of reversions/total *n* = 56/155, odds ratio 3.74 [95% CI 1.37–10.2]). The AHEI-to-MetS reversion association was particularly evident among participants with central obesity and among those with high triglycerides (Table 1). Furthermore, adherence to AHEI was associated with a 5-year reversion of the high triglyceride component (*n* = 276/767, 1.61 [1.12–2.33]) but the association with reversion of central obesity did not reach statistical significance (*n* = 75/481, 1.42 [0.75–2.68]). Analyses with average AHEI score across phases 3 and 5 as the exposure largely replicated these findings (online appendix Table A5).

CONCLUSIONS — In the present report, we show that adherence to dietary guidance for healthy eating, the AHEI, is associated with reversion of the MetS in a middle-aged population. Although several studies have investigated the diet-to-MetS prevalence and incidence relationships, the impact of diet on MetS reversion has only been studied in two clinical trials assessing adherence to the Mediterranean diet in two Mediterranean countries. One trial of 180 Italian subjects found the Mediterranean diet intervention to lead to reversion of MetS (3), the other larger trial (*n* = 1,224, Spanish) suggested that the observed effect was due to the effect of nut supplements rather than the Mediterranean diet as a whole (4). Even though the clinical utility of MetS as an independent predictor of CVD has been challenged (11), our findings, from a non-Mediterranean country, are novel and strengthen evidence of the potential impact of diet in countering increasing levels of risk factors associated with CVD and type 2 diabetes.

We observed a stronger impact of AHEI on MetS reversion in participants with central obesity and high triglycerides. Among all baseline MetS case subjects, AHEI was associated with reversion of the high triglyceride component but not the central obesity component. Thus, reduction of visceral fat (12) leading to a decrease in the flux of free fatty acids and increased insulin resistance—a key feature in MetS pathophysiology (13)—seems an unlikely explanation for our findings. However, further research is needed to examine these and other plausible mechanisms. These may include counteracting oxidative stress (and related insulin resistance) (14) via antioxidants from fruits, vegetables, and long-term multivitamin use and the lowering of high triglyceride levels—linked to reduction of inflammation processes involved in MetS (15)—as a result of increased consumption of polyunsaturated fat, nuts, and soy and a reduced consumption of *trans* fat.

Limitations of this study include the small sample size that does not fully represent the British population (6) and that does not allow ethnic group substratification other than White or non-White, thereby limiting the generalizability of our findings; the lack of objective measure of physical activity; and the use of the FFQ, recognized to be less precise than diary questionnaires, to assess diet.

Despite these limitations, our findings emphasize the potential benefits of adherence to the dietary recommenda-

tions of the AHEI in middle-aged individuals with MetS, especially those with central obesity or high triglyceride levels.

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T.N.A. designed the study, conducted the analyses, cowrote the initial and final drafts and is guarantor. A.S.-M. designed the study and reviewed/edited the manuscript. A.G.T., M.J., and M.V. reviewed/edited the manuscript. J.E.F. designed the study and reviewed/edited the manuscript. M.G.M. designed the study. M.J.S. advised on the analysis and reviewed/edited the manuscript. M.K. designed the study, helped in planning the analyses, and cowrote the initial and final drafts.

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